The Superintendent of the United States Coast and Geodetic Survey furnishes the following information in regard to this earthquake:

A letter from Mr. P. H. Dike, the Magnetic Observer at Vieques, Porto Rico, contains the following data regarding the earthquake of August 27, 1904, as recorded on the Bosch Omori seismograph at that place. The seismograph records both the north-south and east-west components of horizontal motion.

The time is reduced to seventy-fifth meridian time.

	N. S.	E. W.
	h. m. s.	h. m. s.
Time of beginning	5 08 40	5 08 48
Time of maximum	5 40 06	5 36 06
Time of ending	6 58 31	6 49 19
Maximum double amplitude of actual displacement of earth at seismograph	4. 2 mm.	3. 3 mm.
Period of pendulum (kept constant)	26. 3 sec.	24. 7 sec.
Ratio of magnification	10	10

A letter from Mr. W. F. Wallis, Magnetic Observer at Cheltenham, Md., states that the magnetograph records show the disturbance very plainly, it being especially well marked in the horizontal and vertical intensity traces, both on Eschenhagen and Adie instruments.

Five distinct shocks can be recognized, the approximate times of which are: $5^h 06^m$; $5^h 23^m$; $5^h 26^m$; $5^h 31^m$, and $6^h 21^m$, seventy-fifth meridian time, counting from 0^h at midnight to 24 hours.

A newspaper report at the time states that a violent earthquake was felt at San Martin in the State of Oaxaca, Mexico, accompanied by "deafening subterranean rumblings."

DR. GEORGE W. HAY.

Dr. George W. Hay, observer and translator in the Weather Bureau, died at Washington, D. C., August 11, 1904. Doctor Hay was born at Conesville, N. Y., August 10, 1847. In December, 1874, he enlisted in the Signal Corps of the Army, in which service he remained until the organization of the Weather Bureau, when he was transferred to the civil establishment, in which he continued until his death, the two periods extending almost thirty years. Doctor Hay was a man of high personal integrity, thoroughly conscientious in the discharge of his duties, unobtrusive in manner, kindly and affable in disposition.

CORRIGENDA.

Monthly Weather Review for July, 1904, p. 329, under "Weather of the Month" for "in charge of Division of Meteorological Records" read "Chief of Division of Meteorological Records."

Monthly Weather Review for July, p. 316, column 1, 17th line, under fig. 2, for $\dfrac{b + J'}{L}$ read $\dfrac{b + J}{L}$.

Monthly Weather Review for April, p. 173, column 2, paragraph 2, line 6, for "$38\frac{1}{2}$" read "$58\frac{1}{2}$."

NOTES AND EXTRACTS.

THE PRIMARY AND SECONDARY RAINBOWS.

When the sunlight falls upon a drop of rain, even though the raindrop be rapidly falling, yet so quick is the action of light that it goes through the drop and passing on enters the eye of the observer, as though the drop were stationary. Now a drop of water can reflect sunlight as nicely as does a mirror. It can also refract or bend the rays of light as does a glass prism. If a prism or a piece of broken glass be properly held in the sunshine, the many different colors that are produced may be perceived. There is the whole range through red, green, yellow, and blue up to the indigo and violet, that constitutes a spectrum. When a ray of light passes through a drop of water it produces a spectrum somewhere so that one will see it and enjoy the beautiful colors if his eye is in the right position. Now, when the sun's rays, SS, fall upon a drop at A_1, some of them enter the drop at a, are reflected at b back to the point c, where they come out and form the spectrum, vr. If the observer is at O he may see the violet part of the spectrum. There is another drop, A_2, a little way above A_1, which produces a similar spectrum, but the red ray is the one that comes down toward the observer at O so that he sees the violet ray below and the red ray above with a beautiful spectrum between them. Now, somewhere above these drops there may be another one, A_3, so located that a ray from the sun may enter this drop at the point m, be reflected twice within the drop at o, p, and issue from it at q in such a direction that red rays may enter the observer's eye at O. A little above A_3 may be another drop, A_4, into which a similar ray of sunlight enters and after two internal reflections sends its violet ray to the observer's eye at O.

Thus it will happen that the drops between A_1 and A_2, although themselves invisible, send to the observer at O the bright beams of light that make up a bright spectrum or band of colors having the violet below and the red above. This is called the primary rainbow, because it is the brightest and the one most frequently seen. The drops between A_3 and A_4 send to the observer at O the other set of colors forming the secondary rainbow, having the red below and the violet above. These latter colors are not quite so brilliant as those of the primary, principally because the light was reflected twice within the drops and much of its color thereby lost. The secondary rainbow is not seen so often as the primary, because the sun has to be lower down near the horizon in order to bring it out perfectly.

The reason why these two rainbows have their colors arranged in opposite directions is not because the secondary is a reflection of the primary bow, as is often said. There is nothing in the sky like a mirror from which the primary bow could be reflected. If we look into a basin or pond of water we may, indeed, see the primary bow reflected, but in this case not only are the colors turned upside down, but the whole arch of the bow is inverted. Now, the arch of the secondary rainbow is not inverted, but is parallel to that of the primary; it is only the order of the colors that is inverted, and this inversion is the result of the two reflections within the drops A_3 and A_4 by which the path of the ray crosses on itself. The one reflection inside of drops A_1 and A_2 gives a direct path in which the lines do not cross each other. It is the crossing of the lines Sm and qr, and not the reflection of the arch as a whole, that inverts the order of every individual color spectrum.

In addition to the color of the brilliant primary rainbow, there are sometimes beautiful fringes of color close along the edges of the primary, and these are called supernumerary bows.

The primary rainbow is formed of arcs of circles whose radii vary from 39.6° for the violet to 42.1° for the red. Its center is at a point directly opposite the sun as seen by the observer. If the sun is in the horizon the bow will be a complete semicircle, having its center in the opposite horizon. The higher the sun is above the horizon, so much the lower must the center be below the horizon. If the sun should be 40° above the horizon, then the rainbow would be almost wholly below and we could only see a small bit of color just above the horizon. Therefore, the only time when we can see the rainbow is when the sun is not too high. Consequently, we rarely see them in the middle of the day. Rainbows can be formed only when the sun shines upon rather large drops of water. Very small
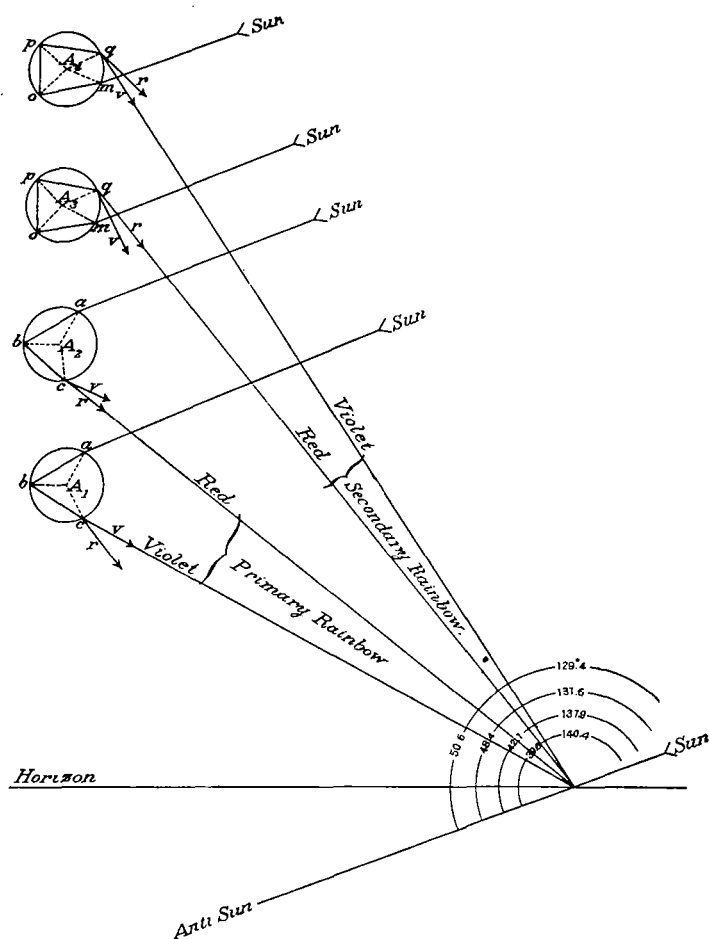
Fig. 1.

drops, like those of a fog or cloud, produce other phenomena called glories and halos. It is the large raindrops that make the finest rainbows, but these large raindrops occur principally in the warmer half of the year and especially in the afternoon thunderstorms. Therefore it is that we see more rainbows during summer afternoons when the sun is nearing the horizon then at any other time. It is not impossible for them to occur at other times, and they can always be seen in the early morning or late afternoon in the falling drops of a fountain or waterfall; sometimes also in the dew-drops on a lawn. Attempts have been made to photograph the rainbow and to a certain extent have been successful, but the colored lights are much fainter than the white light above and below it; one needs a dark background to bring out the rainbow effectively. Moreover, one can not photograph all colors of the spectrum on any one sensitive plate. The plate that will photograph the blue end will not show much of the red, and visa versa, and of course the ordinary photographs do not show the colors, but only black and white. It will merely show a bright arc corresponding to that color band in the rainbow to which the plate is specially sensitive, if indeed the diffuse light from the clouds does not entirely obliterate the photographed image of the colored bows because the latter are not very rich in actinic rays.—*C. A.*

FORMATION AND MOVEMENT OF HURRICANES.

A correspondent writes:

If I take a flask of saturated air at atmospheric pressure and absorb all the moisture in it by chemical combinations or by condensation, a partial vacuum is produced, and if I then remove the stopper there is an inrushing of air to complete the equilibrium.

On this fact as a basis he builds up the theory that the condensation of moisture in the free air and its deposition as rain

relieve the atmosphere of a certain weight and volume, thereby producing an inflow of air from all sides and the resultant phenomena of a whirlwird or hurricane. This is essentially the theory elaborated by H. W. Brandes and summarized in his Beiträge zur Witterungskunde in 1820. Simultaneously with Brandes in Germany, Espy was carrying on his studies in the United States, and in 1826, or soon after, he came upon the idea that the condensation of atmospheric moisture into cloud and rain, while it might relieve the atmosphere of a small percentage of its weight, must on the other hand involve a great quantity of latent heat, thereby expanding the neighboring air, so that we can not properly speak of the formation of a partial vacuum. The air accompanying the condensed moisture expands, has a smaller specific gravity, and will therefore be pushed upward by buoyancy. Its expansion counteracts all tendency to low pressure.

An excellent exposition of this phase of the problem is given by Professor Hann in the Meteorologische Zeitschrift for 1874, a translation of which will be found on pages 393–396 of the Annual Report of the Smithsonian Institution for 1877.

It therefore becomes at once evident that the low pressure at a storm center does not represent the mere loss of the weight of the falling rain, but that the evolution of latent heat produces a buoyancy that itself produces an upward current, whence follows an inflow to supply the place of the ascending air. This inflow may in the rarest of cases be directed exactly toward the center, and Espy maintained that in all cases of small storms on land the observations showed such a direct radial motion inward. On the other hand, Redfield showed that in large storms on the ocean the rotary or circular motion was much more prominent. Both these and numerous European students described the low pressure within the storm area as due to the centrifugal force developed by the rotation around the storm center. Ferrel showed that this was not sufficent, except possibly in the tornadoes and dust whirls, but that in all large storms on land and ocean an additional centrifugal force, which he calls a deflecting force, due to the rotation of the wind with the earth around the earth's axis must also be considered. These combined centrifugal forces increase with the velocity of the wind relative to the earth's surface, and the velocity of the earth's surface about its axis, which latter depends upon the latitude. An excellent exposition of the whole subject was given by Dr. Julius Hann in the Meteorologische Zeitschrift for 1875, a translation of which is published on pages 426–444 of the Annual Report of the Smithsonian Institution for 1877. We quote the following paragraphs from the concluding pages of this report:

Excess of heat or increased amount of aqueous vapor is the first cause of the ascent of air and its influx from all sides. The inflowing air ascends, condenses its aquous vapor, whereby its ascensional power is further increased, and from this cause the disturbance can continue for some time. For reasons previously given, this process can, in the equatorial regions, give rise at most to tornadoes only, and in fact Reid's chart shows no cyclone traced back to 10° latitude, no typhoon traced beyond 9°. The greater expansion of the air in consequence of higher temperature and greater quantity of vapor must without doubt exert an influence upon the barometric pressure. Notwithstanding this, that theory is untenable which ascribes all barometric variations to the condensation of cyclonic vapor, for according to it the variations of atmospheric pressure would be greatest at the equator. The atmosphere is exceedingly mobile. Every disturbance of equilibrium will be quickly restored by an inflow of air, provided no whirl arises. If, therefore, the earth had no rotation about an axis, there would the nonperiodical barometric variations nowhere be greater than they are at present at the equator. * * *

The progressive motion of cyclones can be explained by the inequality of the centrifugal forces on the polar and equatorial sides of a cyclone. The term of the gradient depending on $2\,n \sin \phi$ is greater on the polar than on the equatorial side, while the other moments remain the same. The cyclone therefore moves toward the direction of the greater diminution of pressure, or toward higher latitudes. It is therefore not necessary to assume that a real transfer takes place from the equator to the pole of the mass of air that forms the cyclone. The deviating force